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The views expressed in this paper are those of the authors.
No responsibility for them should be attributed to the Bank of Canada.

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Abstract

In this study we statistically quantify the reactions of Canadian and U.S. interest rates to macroeconomic announcements released in Canada and in the United States. We find that Canadian interest rates react very little to Canadian macroeconomic news and are significantly affected by U.S. macroeconomic news, which indicates that international influences on the Canadian fixed-income markets are important. Moreover, we find little evidence that Canadian interest rates have become more sensitive to Canadian macroeconomic announcements over time. This suggests that Canadian market participants have gained little understanding of which macroeconomic variables condition the Bank's monetary policy reaction function and that the Bank of Canada's efforts, since the early 1990s, to make its conduct of monetary policy more transparent to the public have not been fruitful. We hypothesize that the lack of fixed monetary policy announcement dates in Canada prior to December 2000, and the Bank's efforts to, on occasion, smooth destabilizing fluctuations in foreign exchange rates, have contributed to the inability of Canadian market participants to better understand the monetary policy reaction function.

JEL classification: E0, E4, E5
Bank classification: Interest rates; Monetary policy implementation; Financial markets

Résumé

Les auteurs tentent de quantifier statistiquement la réaction des taux d'intérêt au Canada et aux États-Unis à la publication des données macroéconomiques dans ces deux pays. Ils constatent que les taux d'intérêt canadiens réagissent très peu aux nouvelles concernant le comportement récent des indicateurs macroéconomiques canadiens mais beaucoup à celles en provenance des États-Unis, ce qui indiquerait que la conjoncture internationale exerce une grande influence sur le marché canadien des titres à revenu fixe. En outre, les taux canadiens ne semblent pas être devenus plus sensibles avec le temps au dévoilement des données canadiennes. Ces résultats donnent à penser, d'une part, que les participants aux marchés canadiens ignorent toujours quelles variables macroéconomiques entrent dans la fonction de réaction de la politique monétaire de la Banque du Canada et, d'autre part, que les efforts déployés par la banque centrale depuis le début des années 1990 en vue d'accroître la transparence de cette politique ont été vains. Selon les auteurs, le fait que les modifications du taux officiel d'escompte n'étaient pas annoncées à dates fixes avant décembre 2000 et les interventions occasionnelles de la Banque visant à niveler les fluctuations déstabilisatrices du taux de change expliquent en partie pourquoi les participants aux marchés ne comprennent pas mieux la fonction de réaction de la politique monétaire canadienne.

Classification JEL : E0, E4, E5
Classification de la Banque : Taux d'intérêt; Mise en oeuvre de la politique monétaire; Marchés financiers

1. Introduction

Small open economies, and their financial markets, are affected by international economic developments, in particular by economic conditions in large countries with which they have important links in terms of international trade and capital flows. As such, they are strongly influenced by the level of interest rates in the rest of the world. Therefore, it is useful to study the reactions of Canadian financial markets to economic events that occur outside of Canada, particularly in the United States. In fact, anecdotal evidence indicates that Canadian market participants tend to put much greater emphasis on U.S. macroeconomic data releases than on Canadian ones. Many Canadian market participants note that they do not trade on any Canadian macroeconomic news events. Thus one purpose of this study is to statistically quantify market reactions to macroeconomic announcements in Canada compared with those made in the United States. In doing so, we also examine the role that the integration of global financial markets plays in the asset price movements of a developed open economy.

Quantifying the reaction of Canadian market participants to macroeconomic announcements is of interest since it sheds some light on how efficiently financial markets process new information (i.e., the efficient market hypothesis) and indicates the degree to which financial markets are integrated. However, quantifying the market participants' reaction to macroeconomic announcements is also motivated by a second and perhaps more important goal for a monetary authority, namely to assess the markets' perception of the authority's monetary policy reaction function.

A long line of research documents the movement of financial asset prices in reaction to news releases. Fleming and Remolona (1997) review some of the literature. Recent research that examines the efficiency of financial markets and/or the markets' perception of a central bank reaction function includes Fleming and Remolona (1999) and Clare and Courtenay (2001), who use intraday data to examine asset price reactions to the release of macroeconomic announcements such as inflation, GDP, and employment, in the United States and United Kingdom, respectively. Joyce and Read (1999) and Brooke, Danton, and Moessner (1999) use daily data to examine U.K. asset price reactions to economic news.

Over the 1990s, the Bank of Canada put considerable effort into making the conduct of monetary policy more transparent to financial market participants. The Bank put forward initiatives, such as the semi-annual release of its *Monetary Policy Report*, to help market participants better understand the Bank's monetary policy reaction function. Thus by increasing the transparency of its monetary policy conduct, the Bank endeavoured to increase the markets' degree of

understanding about its reaction function's dependence on domestic economic conditions. In other words, by implementing transparency measures, the Bank hoped to reduce the markets' uncertainty toward the set of macroeconomic variables that condition the Bank's reaction function.[1] Muller and Zelmer (1999)[2] discuss the benefits of reducing market uncertainty about the central bank's reaction function.

Haldane and Read (2000) show that a reduction in the markets' uncertainty about the central bank's reaction function implies that market prices will react less to monetary policy changes since market participants are better able to anticipate them. This implies that the markets' better knowledge of the central bank's reaction function causes the markets to react more fully to news about the state of the economy, in particular macroeconomic data releases on which the reaction function is (in part) conditioned. Consequently, markets should react to macroeconomic announcements they view as important arguments to the monetary policy reaction function and, moreover, should react more strongly to those unanticipated data releases that have greater impact on potential future monetary policy.[3] Thus, in a world where the central bank's reaction function was known to the market participants with certainty, one would in principle observe no financial asset price reactions at the time of monetary policy changes, but significant reactions to the release of surprise macroeconomic data that occur *before* the monetary policy action date.

Empirically, one would expect to find that for countries with well-understood central bank reaction functions, macroeconomic announcement surprises have significant explanatory power for asset price changes (at daily or higher frequencies), with monetary policy changes having little significance. In countries that have a reaction function that is less well understood, the results should be the reverse. Haldane and Read (2000), using daily measures of forward interest rates in the United Kingdom, find empirical evidence that the Bank of England's efforts at greater transparency have in fact decreased the markets' reaction to official interest rate changes. In Canada, Muller and Zelmer (1999) test empirically whether the efforts to increase the Bank of Canada's level of transparency have in fact decreased the markets' reactions to official monetary

1. Another often-cited motivation for making the conduct of monetary policy more transparent is that it imposes greater accountability on the monetary policy authorities. This study does not address that issue. See Mishkin (2000) for a discussion of central bank accountability.
2. See Buiter (1999), Tarkka and Mayes (1999), and Issing (2000) for more on the possible welfare effects of monetary policy transparency.
3. Poole and Rasche (2000) make similar arguments. Moreover, they show that FOMC decisions may cause the market's expectation of future monetary policy moves, as proxied by the one-month-ahead federal funds futures contract, to change. However, they also show that macroeconomic announcements have a strong impact on expected future target rates. Consequently, they argue that market participants have—since February 1994, a period where they argue the Federal Reserve has improved monetary policy transparency—a better understanding of the Federal Reserve's monetary policy reaction function.

policy rate changes. They use a method similar to that used by Haldane and Read (2000) to examine foreign exchange and yield curve reactions to Bank of Canada monetary policy actions. They find evidence that interest rate reactions to Bank of Canada monetary policy changes have decreased since February 1996.[4]

Although the Bank has attempted, through various changes in its operating procedures (outlined by Muller and Zelmer 1999), to reduce the markets' degree of reaction-function-uncertainty, there remained, until December 2000, a possibly substantial barrier to enhancing the markets' understanding of its reaction function: uncertainty as to the timing of official rate changes given the Bank's lack of fixed announcement dates for monetary policy decisions. (In December 2000, the Bank adopted a fixed announcement date (FAD) regime whereby the dates on which it announces target rate changes are fixed at least one year in advance.)[5]

It has been argued that without fixed monetary policy announcement dates, market participants do not understand the role domestic macroeconomic data play in influencing the timing and direction of the monetary policy decisions. With fixed intervals of time between monetary policy decisions, market participants can relate the central bank's action or, more importantly, *lack of action*, on a fixed announcement date to a specific set of data releases accumulated since the last FAD. When a central bank does not have fixed monetary policy announcement dates, market participants have great difficulty relating the central bank's lack of monetary policy action (on any one day) to a set of macroeconomic announcements released up to that day.[6]

These arguments are consistent with the work of Poole and Rasche (2000), who show that since February 1994—a period where the FOMC has refrained from changing rates between meetings—market participants have been better able to anticipate FOMC decisions. They argue that before this period, when the FOMC changed the target rate more frequently at unscheduled times between meetings than it did at meetings, market participants were less likely to correctly anticipate the FOMC decisions. Moreover, they note that confining monetary policy decisions to

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4. Work that examines interest rate reactions to monetary policy decisions in other countries includes Hardy (1996), Thornton (2000), Kuttner (2000), Poole and Rasche (2000), Zielinski (2001), and Matousek (2001).
5. This study was initiated before the Bank of Canada moved to a fixed announcement date regime.
6. Market commentators noted that, in an environment where monetary policy announcement dates were not pre-announced, financial market participants found it almost impossible to anticipate the timing of Bank of Canada rate changes based on the release of recent domestic macroeconomic data. This in effect leads market participants to put little effort into examining the possible impact of these data releases on the future path of monetary conditions. However, Canadian market participants (and in turn interest rates) may react to other information, such as FOMC decisions or data that help anticipate FOMC decisions, to the extent that it helps predict the timing and direction of Bank target rate changes.

scheduled dates decreases the probability that the markets will misinterpret the significance of the timing of the monetary policy actions. However, they indicate that the FOMC, by refraining from moving outside of meeting dates *and* by announcing their rationale for the policy decisions to the public via press release immediately after they meet, improves the market's ability to forecast monetary policy actions. Although the Bank of Canada has, since February 1996, announced to the public any changes to its target rate, as has the FOMC since February 1994, the Bank of Canada had not, until December 2000, introduced fixed monetary policy announcement dates.

The Bank's (occasional) attempts to smooth exchange rate volatility also pose a barrier to enhancing the markets' understanding about which macroeconomic variables condition the Bank's reaction function. Through the 1970s, 1980s, and 1990s, the Bank on occasion found it necessary to raise official interest rates to counteract what it perceived to be destabilizing exchange rate dynamics.[7] As explained in Murray, Zelmer, and Antia (2000), the Bank would, for "tactical" reasons, tighten monetary policy, not because tighter conditions were required to offset inflationary pressures, but to calm markets to avoid larger interest rate increases that would otherwise occur across the yield curve as a result of foreign exchange market instability.

However, this can encourage market participants to perceive these actions as attempts to target something other than inflation; i.e., the exchange rate. The Bank's occasional deviation from its inflation-targeting monetary policy reaction function would itself make it difficult for market participants to learn about this reaction function. Moreover, if these tactical rate changes occurred frequently enough, they would in principle induce market participants to minimize their efforts to understand the Bank's inflation-target-based reaction function.[8] Given that the most recent episode in which the Bank acted to calm exchange rate volatility was in late August of 1998—substantially after the last of its transparency-improving operational changes—it seems likely that market participants continue to perceive the Bank as having some exchange rate targeting intentions.

Although Muller and Zelmer (1999) find evidence that interest rate reactions to monetary policy actions have decreased over time, they note that their results are also consistent with the possible existence of some unobserved factor that is not associated with the increased transparency of the conduct of monetary policy. For example, there may have been a convergence of the Canadian

7. The Bank was concerned that extrapolative expectations would take hold in the exchange markets, leading to self-reinforcing declines in the rate, and that sudden depreciations would feed back into fixed-income markets, causing interest rates to increase to levels above those desired by the Bank.
8. Freedman (2001) notes that the Bank's use of a Monetary Conditions Index (MCI) may have caused market participants to treat it as a short-term policy target. This too would likely reduce the market's understanding of the implications of economic news for the Bank's monetary policy reaction function.

business cycle with that of the United States, whose monetary policy reaction function seems less uncertain to market participants. Another explanation for their findings is the fact that four out of the last five official rate changes (within the Muller and Zelmer sample period) occurred within 24 hours after an FOMC meeting date. As market participants came to expect Canadian official rate changes to occur immediately after FOMC meeting dates, this would in principle have allowed them to anticipate the timing of the official rate change in Canada. (See Appendix B for a full calendar description of monetary policy actions in Canada and the United States since 1995.) Thus, evidence indicating a decrease in the market's reaction to monetary policy changes is not sufficient evidence that the market participants have improved their understanding of the Bank's reaction function as a result of the latter's efforts to be more transparent. Evidence indicating an increase in the size of the market's reaction to economic data releases would necessarily corroborate Muller and Zelmer's conclusions that transparency efforts at the Bank have helped to reduce the public's uncertainty towards the Bank's monetary policy reaction function.

This paper aims to provide a more complete test of the hypothesis that greater transparency has reduced public uncertainty toward the Bank's reaction function. By examining the reaction of Canadian interest rates to Canadian data releases, we investigate whether the findings of Muller and Zelmer (1999) are a result of market participants' greater understanding of the Bank's reaction function or other concurrent factors.

Our results indicate that interest rates in Canada react to perhaps one Canadian macroeconomic surprise. In fact, U.S. macroeconomic announcement surprises explain a substantial part of Canadian interest rate movements. Further, when Canadian monetary policy changes are included as an explanatory variable, they are found to be much more important in explaining interest rate movements than the Canadian macroeconomic surprises. In contrast, when we include U.S. target rate changes in a set of U.S. macroeconomic announcement surprises, we find that, although they are statistically significant, they provide relatively little additional explanatory power for U.S. yield changes than provided by the U.S. macroeconomic surprises. Overall, the evidence is consistent with Canadian market participants viewing the Canadian economy as being substantially integrated with the U.S. economy, and/or continuing to have substantial uncertainty about the Bank's reaction function (despite the Bank's efforts). The decrease in asset price reactions to monetary policy changes found by Muller and Zelmer (1999) may be the result of the convergence of the Canadian business cycle with that of the U.S. or the Bank's policy of changing rates immediately after changes made by the FOMC. Moreover, it seems likely that both the lack of fixed announcement dates and the fact that the Bank has acted to calm foreign exchange markets in the recent past substantially impeded the Bank's desire to reduce the public's uncertainty of its reaction function.

This paper is organized as follows. Section 2 discusses the empirical methodology used to assess the asset prices' reaction to macroeconomic announcements. Section 3 presents the data and section 4 the regression results when the set of explanatory variables is restricted to Canadian macroeconomic announcements. This is relaxed in section 5, where we expand the set of explanatory variables to include U.S. macroeconomic announcements for regression of Canadian and U.S. yields. In section 6, we perform some sensitivity analysis of these results by examining subsamples of the data. Section 7 investigates the Canadian yield curve response to official interest rate decisions. Consequently, we draw out the implications for changes in the transparency of monetary policy over time, as perceived by market participants, and the impact of changes in the framework of monetary policy decision-making. Concluding comments are presented in section 8.

2. Methodology

To assess the impact of macroeconomic announcements on asset prices, we use a time-series event-study methodology, following Joyce and Read (1999), among others, in a long line of research in this area.

We estimate the following model for various interest rates:

$$\Delta y_t = \alpha + \sum_{i=1}^{n} \beta_i (x_{i,t} - x_{i,t}^e) + \varepsilon_t \qquad (1)$$

where the sum runs over the number of economic indicators, Δy_t is the daily yield change at the close of business on day t, and $x_{i,t}$ is the actual macroeconomic announcement, while $x_{i,t}^e$ is the expected value of that announcement. Thus $(x_{i,t} - x_{i,t}^e)$ is the unanticipated component, or *surprise*, of the macroeconomic data release. In this study, we examine reactions of Canadian and U.S. yields to surprises in the release of eleven Canadian and eleven U.S. macroeconomic indicators. The variable for the surprise, $(x_{i,t} - x_{i,t}^e)$, is set to zero on days when there was no release of indicator i. The Canadian macroeconomic announcement data cover 2 January 1995 to 25 August 2000, while the interest rate data used in this study extend over the same period.

Because Canada is a small open economy, with direct links to the U.S. economy in terms of trade and capital flows, it should be of no surprise to find that Canadian debt instruments are significantly influenced by U.S. interest rates. Consequently, Muller and Zelmer (1999) examined the reaction of spreads of Canadian over U.S. yields to official interest rate changes. This was of interest since it allowed them to control for Canadian interest rate movements that emanated from

U.S. rate movements, which were in turn caused by various U.S. economic announcements. Of course, a more direct way to control for the effects from U.S. interest rate movements is to examine the Canadian yields' reactions to U.S. macroeconomic announcements. We take that approach in this study. The U.S. macroeconomic announcement data we use cover 2 January 1995 to 1 October 1999. In this way, we are able to measure Canadian yields' reactions in an international capital market framework. We thus also estimate equation (1) once using only U.S. macroeconomic announcements, and then re-estimate equation (1) using both Canadian and U.S. announcements as the independent variables. The U.S. announcement data set is somewhat shorter, however, leading to a reduction in the degrees of freedom. We therefore begin our analysis by examining Canadian interest rate reactions with the longer Canadian macroeconomic announcement data set.

3. Data

3.1 Interest rate data

As the dependent variable in equation (1), we use end-of-day observations of implied yields from 3-month futures contracts (BAX contracts),[9] and yields on 2-, 5-, and 10-year benchmark Government of Canada bonds. We use yields based on exchange-traded futures contracts, rather than spot money-market instruments (such as 3-month commercial paper), because Harvey (1996) has shown that changes in futures' prices tend to respond more quickly than (or lead) other money market rates in their reaction to economic news.[10] We also use U.S. interest rate data, namely end-of-day daily observations of implied rates from 3-month eurodollar futures, as well as 2-, 5-, and 10-year benchmark U.S. Treasury bond yields. Figures 1 to 4 plot the yields used in this study.

9. The implied annualized yields are derived from the front contract on the cash-deliverable index futures contract on 3-month bankers' acceptances traded on the Montreal Exchange. These yields are calculated by subtracting the contract price from 100.

10. To be precise, Harvey (1996) shows, using intraday data, that futures implied yields Granger-cause t-bill rates, implying that the futures market leads the cash (OTC) market after the simultaneous arrival of new information to these markets. Moreover, since the mid-1990s, the Government of Canada t-bill market has been influenced by technical supply factors that may have made t-bill rates less reflective of economic fundamentals. See Harvey and Boisvert (1998) for more details.

Figure 1: Market Interest Rates: Futures Yields (%)

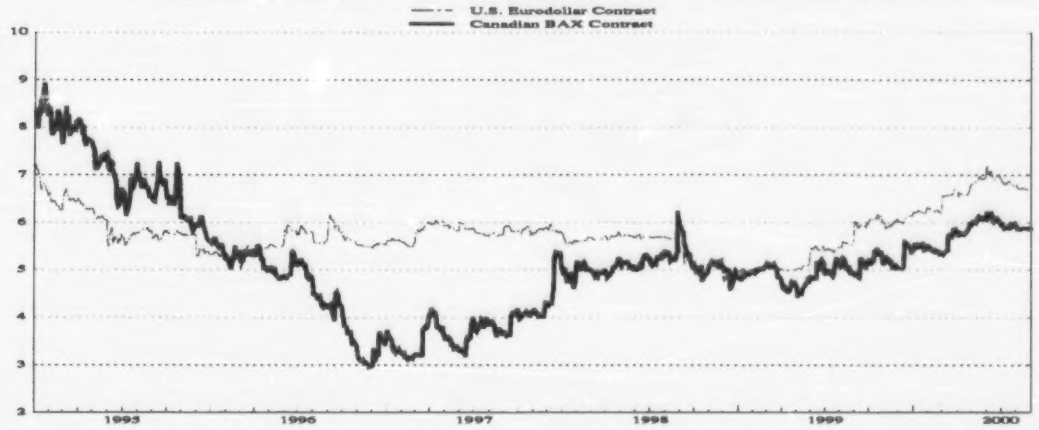


Figure 2: Market Interest Rates: 2-Year Yields (%)

Figure 3: Market Interest Rates: 5-Year Yields (%)

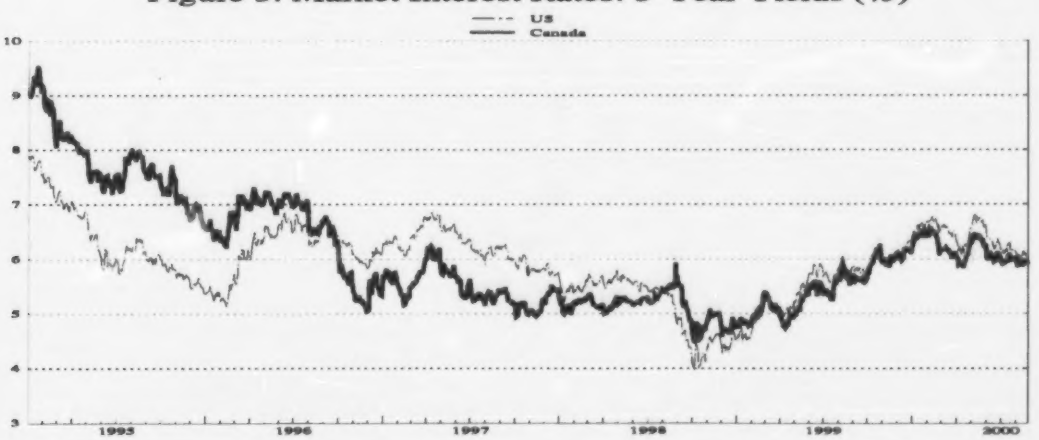
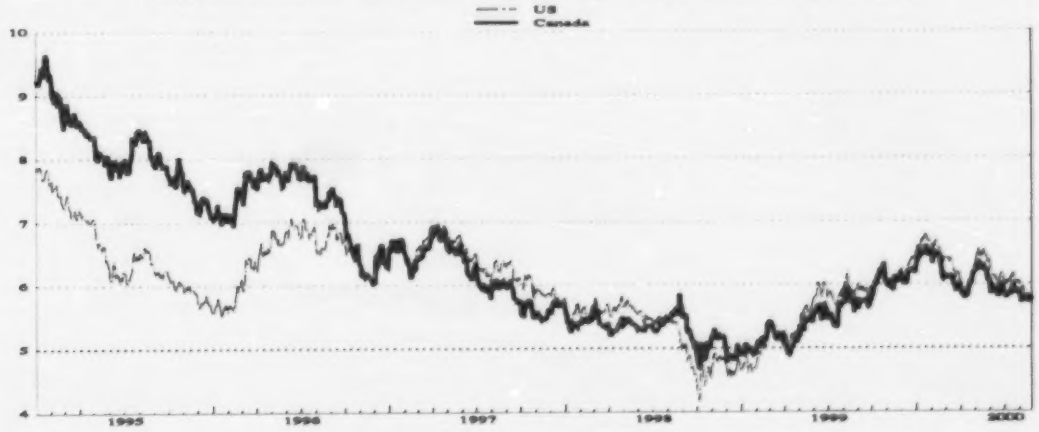


Figure 4: Market Interest Rates: 10-Year Yields (%)



3.2 Macroeconomic announcements data

We use data on actual releases and median survey expectations of eleven Canadian macroeconomic announcements, provided by Standard & Poor's. The indicators used are: (1) CPI, (2) CPI excluding food and energy (CPIEX), (3) producer price index (PPI), (4) real gross domestic product (GDP), (5) unemployment rate (UNP), (6) changes in employment (EMP), (7) wage settlements (WAG), (8) current account (CA), (9) merchandise trade balance (MTB), (10) retail sales (RSL), and (11) raw materials price index (RAW).[11]

To assess the response of financial asset prices to macroeconomic announcement surprises, we need to measure the market's expectations of these variables. They are measured using median survey expectations from survey data provided by Standard & Poor's for the series of Canadian macroeconomic data releases. As stated above, surprises in economic data releases are then measured as the actual data release minus the median survey expectation. Table 1 presents summary statistics for the time series of actual Canadian macroeconomic announcements and the summary statistics for the time series of median expectations from Standard & Poor's surveys of economists. The standard deviations are used to normalize the surprises of the economic data releases in the regression results reported below. This allows one to interpret, in a consistent manner, the estimated coefficients. The mean surprises are in general small compared with the

11. These announcements are released monthly (except for the current account, which is quarterly) at pre-announced dates and times (mostly at 8:30 a.m. Eastern Standard (or Daylight) Time, except for 7 a.m. release times for the CPI and (un)employment figures, and a 10 a.m. release time for the wage data).

standard deviation of the surprises, with employment and the current account surprises showing the largest standard deviations.

Table 1: Summary statistics for Canadian macroeconomic announcements (2 January 1995 and 25 August 2000)

Data	Actual		Median forecast		Surprise	
	Mean	Stdev	Mean	Stdev	Mean	Stdev
CPI	1.678	0.666	1.685	0.686	-0.007	0.188
CPIEX	1.575	0.493	1.572	0.512	0.003	0.185
PPI	0.130	0.478	0.230	0.249	-0.100	0.375
RAW	0.306	2.513	0.236	1.314	0.012	1.692
RSL	0.258	0.919	0.446	0.427	-0.186	0.772
UNP	8.697	1.011	8.709	0.974	-0.012	0.200
EMP	23.642	34.649	26.892	9.631	-3.250	35.042
WAG	1.494	0.670	1.507	0.639	-0.001	0.431
MTB	2.315	0.827	2.366	0.746	-0.035	0.599
CA	-9.918	11.052	-10.627	9.519	0.709	4.868
GDP	0.208	0.346	0.251	0.237	-0.038	0.229

As stated earlier, we also use a set of U.S. macroeconomic announcement data to examine the extent to which Canadian asset prices react to international news releases. Table 2 summarizes the properties of the U.S. macroeconomic indicator releases considered in this paper, as well as their median survey expectations, as provided by Standard & Poor's from their MMS database. As with Canada, both the actual releases and the surprises in the median survey expectations of employment data (i.e. non-farm payrolls in the case of the U.S.) have large standard deviations. Also like Canadian data, the difference between the median survey expectations and the values of the actual indicator releases are close to zero, and the mean differences are much smaller than the standard deviations of the surprises. From the large range of U.S. economic announcements, we consider only eleven, namely changes in non-farm payrolls (USNFP), NAPM (USNAPM), CPI (USCPI), PPI (USPPI), unemployment (USUNEMP), hourly earnings (USHRLYE), industrial production (USINDP), trade in goods and services (USTRDGS), final gross domestic product (USGDPF), housing starts (USHSES), and U.S. retail sales (USRSL). We have chosen these indicators based in part on the study by Fleming and Remolona (1999) on the impact of U.S.

indicators on U.S. fixed-income markets (using intraday data), and on information by dealers from the Bank of Canada about which U.S. indicators affect the Canadian fixed-income markets.

Table 2: Summary statistics for U.S. macroeconomic announcements (2 January 1995 to 1 October 1999)

Data	Actual		Median forecast		Surprise	
	Mean	Stdev	Mean	Stdev	Mean	Stdev
USNFP	196.732	148.096	191.821	56.179	4.911	127.933
USNAPM	51.723	3.653	51.987	3.329	-0.264	2.066
USCPI	0.196	0.132	0224	0.085	-0.030	0.096
USPPI	0.086	0.307	0.153	0.172	-0.071	0.228
USUNEMP	5.007	0.522	5.043	0.514	-0.036	0.142
USHRLYE	0298	0.245	0.283	0.076	0.015	0.231
USINDP	0.266	0.493	0.189	0.349	0.078	0.254
USTRDGS	-11.741	3.821	-11.491	3.269	-0.250	1.683
USRSL	0.273	0.395	0.370	0.311	-0.100	0.304
USGDPF	3.506	1.613	3.500	1.543	0.006	0.273
USHSES	1.498	0.140	1.487	0.121	0.010	0.072

4. Interest Rate Reactions to Canadian Macroeconomic Surprises

Before examining asset price reactions to macroeconomic announcements, we first examined the properties of the Canadian macroeconomic announcements themselves. It is important that the expected component of the announcement surprise represent the consensus opinion across market participants. We do so by examining whether the expectations measured by the survey data satisfy rational expectations, since the market participants individually (and thus on average) are assumed to behave rationally. As such we test to see whether the announcement data are unbiased and test whether they are (weak-form) efficient (i.e., whether the expectations embody all previously released information, including past announcements). The results, presented in Appendix A, indicate that the survey data are consistent with being rational and drawn from the market as a whole.

In this section, we report the results derived by regressing the change in yields on a constant and the surprise measures of the eleven Canadian macroeconomic announcements. The results of estimating equation (1) over the sample of 2 January 1995 to 25 August 2000 are reported in Table 3 for Canadian yields. The coefficients are estimated by ordinary least squares (OLS), with the standard errors calculated using a Newey-West adjusted covariance matrix, which yields consistent estimates in the presence of both heteroscedasticity and autocorrelation.[12] Table 3 reports only the coefficients that were significant at the 5 per cent level.

Table 3: Canadian interest rate response to surprises

Yields	Significant surprises	R^2
Futures	EMP (0.0301, *0.0118*); PPI (-0.0156, *0.0249*)	0.0131
2-year	EMP (0.0308, *0.0083*); RAW (0.0215, *0.0416*); CA (-0.0349, *0.0156*)	0.0152
5-year	EMP (0.0218, *0.0345*); CA (-0.0286, *0.0332*); PPI (-0.0175, *0.0267*); RAW (0.0184, *0.0280*)	0.0128
10-year	PPI (-0.0170, *0.0040*); RAW (0.0180, *0.0060*)	0.0125

Notes: The first number in parentheses is the coefficient; the second number represents the significance level. Estimated using a Newey-West adjusted covariance matrix.

Canadian employment numbers have a significant impact on Canadian yields at short and medium maturities. The employment surprises tend to play a more dominant role across most of the yield curve in Canada. PPI has a significant impact on all yields except the 2-year bond yield, while raw material prices were significant at the 5 per cent level for all yields except the futures yield. In addition, current account surprises are significant for mid-maturity interest rates.

In Muller and Zelmer (1999), the use of interest rate spreads to control for effects originating from U.S. rate movements was predicated on the assumption that Canadian macroeconomic announcements had zero impact on U.S. asset movements. We verify that this is indeed the case by replacing Canadian yields with U.S. yields as the left-hand variable in equation (1). Table 4 shows to which Canadian macroeconomic surprises U.S. yields reacted significantly (again at the 5 per cent significance level) over the 2 January 1995 to 25 August 2000 sample period. For comparison, the impact on Canadian yields is shown again. Overall, the results support this assumption, as all but two Canadian macroeconomic releases are found to be insignificant.

12. Though not reported, LM tests for serial correlation of up to order 20 were carried out for all regressions in this study. Residuals were found to be significantly serially correlated in almost all cases, and thus the Newey-West procedure was used throughout. See Newey and West (1987).

Raw material prices and retail sales have a significant impact on all three U.S. bond yields, with a relatively constant value for the regression coefficients across all three maturities. Canadian raw material prices might affect U.S. yields, since they likely affect U.S. input prices, and thus inflation, via raw materials imported. Canadian retail sales data may be a good indicator of the position in the business cycle, which may have been similar in the U.S. and Canada and therefore had a comparable effect on both countries' interest rate expectations. However, it is not clear why Canadian retail sales or raw material prices need impact U.S. bond yields exactly at the time of their release.

Table 4: Interest rate response to Canadian macroeconomic surprises

Yields	Significant surprises, Canada	R^2 (a-R^2)	Significant surprises, U.S.	R^2 (a-R^2)
Futures	EMP, PPI	0.0131 (0.0053)	None	0.0035 (-0.0046)
2-year	EMP, RAW, CA	0.0152 (0.0073)	RAW, RSL	0.0089 (0.0008)
5-year	EMP, CA, PPI, RAW	0.0128 (0.0049)	RAW, RSL	0.0124 (0.0043)
10-year	PPI, RAW	0.0125 (0.0045)	RAW, RSL	0.0154 (0.0074)

Notes: Estimated using a Newey-West adjusted covariance matrix. Adjusted R^2 (a-R^2) are presented in the brackets adjacent to R^2 measures.

The significance of these Canadian macroeconomic variables may be the result of unobserved (more "causal") U.S. market moving news coinciding with the release of the Canadian figures. This would imply that the significance of these macroeconomic surprises is spurious. In fact, Canadian retail sales announcements have occurred on the same day as several of the U.S. macroeconomic data releases. Over the period studied here, their release coincided five times with the release of U.S. housing starts, six times with the release of U.S. trade in goods and services, once with U.S. retail sales, and once with the final U.S. GDP release.

The significance of Canadian raw material prices on U.S. yields may thus also simply be a statistical artifact. As with Canadian retail sales data, over the period studied the release dates of Canadian raw material prices coincided four times with releases of USGDPF, once each with U.S. housing starts, U.S. retail sales, and USPPI. Thus, given the low R^2 found for regressions of U.S. yields on Canadian macroeconomic data releases, it is likely that the significant findings are simply spurious.

However, the possibility that other Canadian macroeconomic data releases coincide with U.S. data announcements also calls into question the results presented in Table 4, showing the significance of the Canadian surprises for Canadian yields. It is likely that the yields are in fact

affected by U.S. economic data releases (because these may coincide with Canadian announcements), which may have caused them to be spuriously significant. As such, in Section 5, we directly control for coincident U.S. data releases by adding these as additional explanatory variables when estimating equation (1).

5. Interest Rate Responses to U.S. Macroeconomic Surprises

Small open economies are affected by international economic developments, in particular by economic conditions in large countries with which they have important links in international trade. Therefore, it is useful to study financial markets of small open economies not in isolation, but in an international context. A previous study using intraday asset price data has shown that Australian fixed-income markets are significantly affected by U.S. macroeconomic news (Campbell and Lewis 1998). Another study using close-of-business yield data has shown that sterling money-market interest-rate futures and 10-year U.K. government bond yields react significantly to surprises in some U.S. macroeconomic indicators (Brooke, Danton, and Moessner 1999).

As a small open economy, having strong trade and capital market links with the United States, Canada's economy is expected to be affected by developments in the U.S. economy. In this section, we directly quantify the extent to which Canadian interest rates are affected by U.S. economic news. We are not aware of any previous paper that has studied the impact of U.S. economic data surprises on Canadian fixed-income markets.

It is interesting to determine whether the set of U.S. economic indicators that exert an influence on financial markets internationally are the same set of U.S. indicators that affect the U.S. financial markets. Many of the recent studies examining the response of U.S. financial markets to U.S. macroeconomic data surprises were conducted using intraday asset price data (see Fleming and Remolona 1999, for example). To enhance the comparability of those intraday studies with our study using close-of-business data, we calculate the results of the response of U.S. interest rates to U.S. economic indicators.

5.1 U.S. announcement only

As Table 5 shows, among the eleven U.S. macroeconomic surprises considered in this study, only the following indicators affected U.S. and Canadian yields significantly (at the 5 per cent level): non-farm payrolls, NAPM, industrial production, retail sales, unemployment, hourly earnings,

GDP, CPI, and PPI. Of these, the three labour market statistics are released at the same time, namely non-farm payrolls, unemployment, and hourly earnings.

For U.S. non-farm payrolls, the significance level of the regression coefficients for all four Canadian yields are higher than those of the most significant Canadian macroeconomic surprises (presented in Table 3). Three of the U.S. macroeconomic surprises—non-farm payrolls, retail sales, and NAPM—affect Canadian yields at all four maturities, and they have the highest significance levels for the coefficients among all U.S. surprises. The U.S. surprises that affect Canadian yields are a subset of the U.S. surprises that have a significant effect on U.S. yields. U.S. yields are, in addition, affected by USCPI and USPPI. While short-maturity U.S. yields respond to a larger range of U.S. surprises than long-maturity yields, Canadian yields are similarly affected at short and long maturities. The U.S. yield results are consistent with the empirical findings of Fleming and Remolona (1999), who found that USNFP and USNAPM, among other variables, are important for intraday yield curve movements.[13]

Table 5: Interest rate response to U.S. macroeconomic surprises

Yields	Significant surprises, Canada	R^2 ($a\text{-}R^2$)	Significant surprises, U.S.	R^2 ($a\text{-}R^2$)
Futures	USNFP (0.0645, 0.0002); USNAPM (0.0354, 0.0034); USRSL (0.0326, 0.0168)	0.0596 (0.0507)	USNFP (0.0435, 0.0001); USNAPM (0.0194, 0.0012); USCPI (0.0165, 0.0054); USPPI (0.0078, 0.0458); USINDP (0.0181, 0.0058); USRSL (0.0236, 0.0080)	0.1494 (0.1413)
2-year	USNFP (0.0682, 0.0001); USNAPM (0.0321, 0.0424); USUNEMP (-0.0324, 0.0489); USRSL (0.0393, 0.0007)	0.0701 (0.0611)	USNFP (0.0593, 0.0001); USNAPM (0.0290, 0.0000); USCPI (0.0204, 0.0346); USINDP (0.0153, 0.0164); USUNEMP (-0.0235, 0.0279); USRSL (0.0365, 0.0010)	0.1013 (0.0926)
5-year	USNFP (0.0598, 0.0003); USNAPM (0.0294, 0.0383); USINDP (0.0165, 0.0407); USRSL (0.0358, 0.0003)	0.0738 (0.0649)	USNFP (0.0578, 0.0001); USNAPM (0.0323, 0.0000); USUNEMP (-0.0189, 0.0481); USHRLYE (0.0233, 0.0357) USRSL (0.0424, 0.0000)	0.0958 (0.0870)
10-year	USNFP (0.0464, 0.0007); USNAPM (0.0275, 0.0098); USINDP (0.0162, 0.0442); USHRLYE (0.0264, 0.0096); USRSL (0.0323, 0.0000)	0.0743 (0.0654)	USNFP (0.0491, 0.0006); USNAPM (0.0327, 0.0000); USRSL (0.0382, 0.0000)	0.0840 (0.0751)

Notes: The first number in parentheses is the coefficient; the second number represents the significance level. Estimated using a Newey-West adjusted covariance matrix. Adjusted R^2 ($a\text{-}R^2$) are presented in the brackets adjacent to R^2 measures.

13. Fleming and Remolona (1999) conduct some sensitivity analysis by expanding their time interval over which yield changes are measured from five minutes to a full day. They find that, although standard errors increase in doing so, the humped-shape yield curve reaction patterns they found using intraday measures remains generally the same for the most significant surprise variables.

As we saw above, Canadian yields are significantly affected by U.S. macroeconomic news. Moreover, when comparing the adjusted R^2 values from Tables 4 and 5, U.S. economic surprises seem to explain a substantially larger proportion of Canadian yield movements than their Canadian counterparts.

As noted above, some of the release dates (and sometimes even the release times) of the Canadian and U.S. macroeconomic surprises, which were found to be significant in separate regressions, actually coincide. Therefore, by estimating interest rate reactions with only Canadian or only U.S. macroeconomic surprises, a significant coefficient for a Canadian (or U.S.) macroeconomic announcement variable may be a spurious result, since the estimation is likely vulnerable to an omitted-variables problem owing to the coincident release of a U.S. (Canadian) macroeconomic variable at the same time.

In fact, over the period studied, the date of the release of Canadian employment (and unemployment) numbers coincided 36 times with the release of the U.S. labour market data considered here (i.e., non-farm payrolls), 3 times with the release of USNAPM, 13 times with USPPI, and once with U.S. retail sales. We checked the two other Canadian indicators that have a significant impact on Canadian yields, namely the current account and PPI, and found that their release dates did not coincide with any of the U.S. data releases considered here. However, they may nonetheless coincide with other U.S. announcements not included in this study that impact U.S. and Canadian yields. In section 5.2 we attempt to address these concerns by combining both sets of U.S. and Canadian macroeconomic data.

5.2 Combined Canadian and U.S. macroeconomic surprises

In this section, we examine the sensitivity of Canadian yields when the set of Canadian and U.S. indicators are combined in equation (1). To check the robustness of our results, given the coinciding release dates, we investigate the yield curve response by regressing yields on both Canadian and U.S. announcement surprises at the same time.

This practice alters the results for the significance of the surprise variables. As Table 6 shows, for the Canadian interest rate regressions there is a smaller set of significant Canadian macroeconomic surprises. Specifically, when comparing Table 6 to Table 4, for the 2-, 5-, and 10-year yields, the number of significant surprises declines from nine to four. The Canadian futures yield remains affected by the same surprises, with coefficients remaining roughly the same magnitude. For the Canadian bond yields, raw material prices and current account surprises are no longer statistically important, while PPI and, in part, employment surprises continue to be important.

Most of the Canadian surprises that were found to be significant in section 4 are no longer significant for U.S. yields, namely Canadian raw material prices for three of the U.S. bond maturities, and Canadian retail sales for two of the U.S. bond yield maturities. However, Canadian CPI (excluding food and energy) is significant for U.S. 5-year yields, while Canadian retail sales surprises for U.S. long yields continue to be statistically significant at the 5 per cent level. Given the coincident release of Canadian retail sales and CPIEX with other U.S. indicators, and the implausibility of U.S. market participants actually trading on Canadian macroeconomic information, we view the significance of the Canadian surprises for U.S. yields as likely being a statistical artifact.

Overall, in contrast to U.S. yields, very few domestic macroeconomic surprises are important movers of Canadian interest rates. In addition, many of the U.S. surprises have a larger impact on Canadian yields in terms of their coefficient size and level of statistical significance, notably non-farm payrolls, NAPM and retail sales, than the Canadian surprises. A comparison of Table 4 with Table 5 shows that the adjusted R^2 values for the Canadian yield regressions increase substantially when U.S. macroeconomic surprises are used *instead* of Canadian surprises. Moreover, when both sets of surprises are combined, the Canadian yield changes gain very little, in terms of explanatory power, by having Canadian surprises added to the set of U.S. surprise variables (compare the adjusted R^2 values in Table 5 with those in Table 6). This indicates that Canadian interest rates tend to react to a much greater extent to U.S. macroeconomic surprises, confirming much of the anecdotal evidence that Canadian market participants pay little or no heed to Canadian data.

Table 6: Interest rate response to Canadian and U.S. macroeconomic surprises

Yields	Significant surprises, Canada	R^2 (a-R^2)	Significant surprises, U.S.	R^2 (a-R^2)
Futures	PPI (-0.0168, 0.0295); EMP (0.0253, 0.0402); USNFP (0.0644, 0.0002); USNAPM (0.0336, 0.0065); USRSL (0.0334, 0.0135); USGDPF (-0.0264, 0.0411)	0.0728 (0.0551)	 USNFP (0.0435, 0.0001); USNAPM (0.0191, 0.0015); USCPI (0.0160, 0.0068); USINDP (0.0184, 0.0051); USRSL (0.0235, 0.0086)	0.1526 (0.1362)
2-year	EMP (0.0241, 0.0145); USNFPR (0.0681, 0.0001); USNAPM (0.0309, 0.0480); USINDP (0.0179, 0.0368); USGDPF (-0.0219, 0.0180); USRSL (0.0399, 0.0004)	0.0822 (0.0643)	 USNFPR (0.0591, 0.0001); USNAPM (0.0287, 0.0000); USCPI (0.0200, 0.0408); USINDP (0.0161, 0.0132); USRSL (0.0369, 0.0007)	0.1096 (0.0921)
5-year	PPI (-0.0172, 0.0418); USNFPR (0.0597, 0.0004); USNAPM (0.0289, 0.0404); USINDP (0.0181, 0.0223); USRSL (0.0362, 0.0001)	0.0833 (0.0655)	CPIEX (-0.0127, 0.0328); USNFPR (0.0575, 0.0001); USNAPM (0.0320, 0.0000); USINDP (0.0139, 0.0398); USHRLYE (0.0233, 0.0378); USRSL (0.0431, 0.0000)	0.1076 (0.0901)
10-year	CPIEX (-0.0129, 0.0480); PPI (-0.0148, 0.0160); USNFP (0.0463, 0.0009); USNAPM (0.0273, 0.0095); USINDP (0.0175, 0.0290); USHRLYE (0.0265, 0.0102); USRSL (0.0324, 0.0000)	0.0841 (0.0663)	RSL (-0.0167, 0.0439); USNFP (0.0488, 0.0008); USNAPM (0.0325, 0.0000); USRSL (0.0390, 0.0000)	0.0986 (0.0808)

Notes: The first number in parentheses is the coefficient; the second number represents the significance level. Estimated using a Newey-West adjusted covariance matrix. Adjusted R^2 (a-R^2) are presented in the brackets.

The fact that the adjusted R^2s increase very little when eleven additional explanatory variables are added to the interest rate regressions based initially only on U.S. macroeconomic variables (see Table 5 versus Table 6) suggests that all eleven Canadian macroeconomic surprises may be insignificant for Canadian yields. We thus test the hypothesis that the eleven Canadian surprises are jointly not significantly different from zero. The first row in Table 7 shows the results of Wald tests used to examine this hypothesis. The results indicate that, at the 5 per cent significance level, the eleven Canadian macroeconomic data do not significantly affect Canadian 2-, 5-, and 10-year bond yields. Although at the 5 per cent level the hypothesis is rejected for Canadian futures yields, it can not be rejected at the 3 per cent level of significance.

Table 7: Exclusion tests of Canadian macroeconomic announcements

Yields	Futures	2-year	5-year	10-year
Wald test excluding all CAD surprises				
p-value	0.0313	0.1522	0.2361	0.0685
Wald test excluding all but one CAD surprise				
p-value	0.0545[a]			

[a]Exclusion test including all Canadian surprises except PPI.

The second row in Table 7 shows the result of a less restrictive Wald test that examines the exclusion of ten out of the eleven Canadian macroeconomic variables for the futures yield regression. Given that Canadian PPI has the highest level of significance among the set of domestic surprises, we exclude it from the set variables included the Wald test. The results indicate that the hypothesis can not be rejected at the 5 per cent level.[14]

The lack of statistical significance for Canadian macroeconomic data announcements is surprising, given that Canada's external sector, though important, represents less than 30 per cent of GDP. Moreover, the exchange rate is free to float and, although monetary policy formulation does take into account external factors, it still has a domestic economy focus. Thus, the fact that market participants seem to put a greater emphasis on U.S. data releases—to the near exclusion of Canadian data releases—may imply that Canadian market participants have little understanding of which domestic macroeconomic variables condition the Bank's monetary policy reaction function.

These results also seem to contrast those for other open economies such as Australia and the United Kingdom. Campbell and Lewis (1998) show that, although U.S. macroeconomic announcements play an important role in influencing Australian 3-month and 10-year interest rate movements, seven or eight domestic macroeconomic surprises are significant movers (at the 5 per cent level) of these interest rates as well. Similarly, in the United Kingdom, Moessner and Gravelle (2001) find that the set of domestic macroeconomic surprises that are statistically

14. We also tested the joint significance of the eleven Canadian surprises for U.S. yields. Although test results indicated that all eleven Canadian surprises were insignificant for U.S. futures yields, for the longer-maturity U.S. yields test results indicated that ten (excluding CPIEX) of the eleven Canadian surprises were insignificant. However, as previously stated, we believe that this is likely the result of the coincident release of other, perhaps unobserved, U.S. economic news. These results are available upon request.

significant drivers of domestic interest rates range from six for yields under one year to two or three for 5- and 10-year yields, respectively.

6. Subsample Results

In this section we examine the extent to which market participants have, over time, improved their understanding of which macroeconomic variables condition the Bank's monetary policy reaction function. The Bank has implemented substantial changes in its operating procedures in an effort to reduce uncertainty about the conduct of monetary policy. Before adopting a FAD regime in December 2000, the last major change to the Bank's operating procedures was implemented in February 1996, when it decided to henceforth issue a press release that announced the change in the official target rate and explained the rationale for this change (Muller and Zelmer 1999). We divide our original sample period into two samples, with the second sample starting a little over a year after the last major changes in the Bank's operating procedure. By starting the second sample period in June 1997, we assume that market participants have had some time to adjust to the series of operating changes implemented up to and including February 1996, and would view this period as one in which the Bank was conducting its monetary policy in a more transparent manner than before February 1996.

Table 8 shows that the same macroeconomic data remain significant throughout the subsamples. In fact, Canadian employment figures continue to be significant at the 5 per cent level for Canadian 2-year yields, while U.S. non-farm payroll surprises are not for the June 1997 to October 1999 subsample.

Table 8: Canadian interest rate response to surprises: *subsamples*

Yields	Significant surprises		
	1/95–10/99	1/95–5/97	6/97–10/99
Futures	PPI (-0.0168, 0.0295) EMP (0.0253, 0.0402) USNFP (0.0644, 0.0002) USNAPM (0.0336, 0.0065) USRSL (0.0334, 0.0135) USGDPF (-0.0264, 0.0411)	PPI (-0.0196, 0.0193) EMP (0.0473, 0.0319) USNFP (0.0934, 0.0000) USNAPM (0.0336, 0.0397) USRSL (0.0448,0.0278)	PPI (-0.0318,0.0201) USNFP (0.0232, 0.0431) USGDPF (-0.0264, 0.0206)
2-year	EMP (0.0241, 0.0145); USNFP (0.0681, 0.0001); USNAPM (0.0309, 0.0480) USINDP (0.0179, 0.0368) USGDPF (-0.0219, 0.0180)	EMP (0.0447, 0.0109) USNFP (0.0991, 0.0000) USGDPF (-0.0317, 0.0442) USRSL (0.0528, 0.0006)	EMP (0.02015, 0.0445) USINP (0.0215,0.0002) USTRDG (-0.0245,0.0084)
5-year	PPI (-0.0172, 0.0418); USNFP (0.0597, 0.0004) USNAPM (0.0289, 0.0404) USINDP (0.0181, 0.0223)	PPI (-0.0231, 0.0421) USNFP (0.0798, 0.0011) USRSL (0.0433, 0.0008)	 USNFP (0.0311, 0.0203) USNAPM (0.0395, 0.0160) USINDP (0.0187, 0.0004) USTRDG (-0.0175,0.0305)
10-year	CPIEX (-0.0129, 0.0480); PPI (-0.0148, 0.0160); USNFP (0.0463, 0.0009) USNAPM (0.0273, 0.0095) USINDP (0.0175, 0.0290) USHRLY (0.0265, 0.0102)	 PPI (-0.0192, 0.0164) USNFP (0.05778, 0.0058) USHRLY (0.0330, 0.0078) USRSL (0.0371, 0.0000)	CPIEX (-0.0106, 0.0222) USNFP (0.0301, 0.0184) USNAPM (0.0436, 0.0022) USRSL (0.0235, 0.0263) USCPI (0.0276, 0.0270) USTRDG (-0.0136,0.0219)

Notes: The first number in parentheses is the coefficient; the second number represents the significance level. Estimated using a Newey-West adjusted covariance matrix.

Although these subsample findings indicate that Canadian yields react to two or three Canadian macroeconomic news releases, the implications of greater transparency in the conduct of Bank monetary policy would be an increase in interest rate reactions to domestic economic data releases as participants attempt to anticipate monetary policy changes. The results presented in Table 8 give little indication that Canadian interest rates are increasingly sensitive to a greater array of Canadian data. Nor is there consistent evidence of an increase in the size of the reaction for the existing set of significant Canadian macroeconomic data releases.

We examine this issue in greater detail by again testing the hypothesis that the eleven Canadian macroeconomic surprises are jointly not significantly different from zero. Table 9 shows the results of Wald tests used to examine this hypothesis over the two subsamples. The results indicate that Canadian macroeconomic announcements display no discernible increase in significance in the second, in principle more transparent, period. In fact, the hypothesis is rejected in the first period for Canadian futures yield movements, while it cannot be rejected in the second subsample, indicating that the set of eleven macroeconomic surprises decreased in importance for explaining Canadian futures yield movements.

Table 9: Exclusion tests of Canadian macroeconomic announcements over subsamples

	Canada Interest Rates (1/95–5/97)				Canada Interest Rates (6/97–10/99)			
Yields	Futures	2-year	5-year	10-year	Futures	2-year	5-year	10-year
p-value	0.0221	0.2899	0.5737	0.2688	0.1261	0.1469	0.3268	0.2731

One explanation for these results is the fact that four out of the last five target rate changes by the Bank (before the end of our sample) were implemented after FOMC decisions (see Appendix B). This reinforces the Canadian market participants' focus on factors, such as U.S. macroeconomic data announcements, that provide information about the probability and direction of U.S. target rate changes. Moreover, a tendency to follow U.S. rate changes may have allowed market participants in Canada to more easily anticipate Bank of Canada target rate changes. This would lead market participants to correctly anticipate Bank moves, which is consistent with the empirical results of Muller and Zelmer (1999), indicating that market reactions to target changes became smaller over time. But this policy would have the perverse effect of reinforcing the Canadian market participants' focus on U.S. macroeconomic variables, and would reduce the participants' incentives to learn about the domestic variables that condition the Bank's monetary policy reaction function.

However, because the full sample period is relatively short—comprising only about four years of data—it is possible that the later subsample is too short for it to pick up, statistically, any meaningful changes in the market participants' reaction (as reflected in daily movements in Canadian rates) to the release of macroeconomic news. Another caveat is that there has been a convergence of U.S. and Canadian business cycles over the last third of the 1990s, which may have caused "made in Canada" asset reactions to be subsumed in those reactions to U.S. economic data releases.

7. The Impact of Monetary Policy Changes in Each Country

As argued in the introduction, lower uncertainty about the Federal Reserve's monetary policy reaction function would imply that macroeconomic news should play a more important role, relative to monetary policy changes, in explaining interest rate responses in the U.S., than is the case for other countries whose reaction function is less well understood. However, as noted in section 5.2, U.S. macroeconomic announcements tend to dominate their Canadian counterparts in terms of ability to explain Canadian interest rate movements.

Haldane and Read (2000) and Muller and Zelmer (1999) investigate the reaction of yields to monetary policy decisions, but ignore the reaction of yields to macroeconomic news. We examine the relative degree of reaction function uncertainty across countries by adding a monetary policy decision variable to the set of macroeconomic announcement variables when regressing interest rate changes on macroeconomic surprises for both Canadian and U.S. interest rates. Specifically, changes in the official interest rate in Canada, which we calculate as changes in the midpoint of the operating band for the overnight interest rate, or in the U.S., which are calculated as changes in the target federal funds rate, are used as additional independent variables when estimating equation (1). The paths of official interest rates are shown in Figure 5, while Appendix B provides the dates and the size of target rate changes in Canada and the United States.

Figure 5: Official Interest Rates (%)

As described in Poole and Rasche (2000), the FOMC has, since 1994, refrained from moving the target federal funds rate outside of its fixed set of meeting dates—ostensibly implementing monetary policy changes within a FAD regime.[15] Given this fact, it would be interesting to

15. Thornton (1996) notes that the FOMC also began in February 1994 to disclose any changes to the target federal funds rate immediately after its meetings.

examine the markets' reaction on meeting dates on which the FOMC did not change the target federal funds rate. It is possible that no change in official interest rates could provoke interest rate movements, since they too might be viewed as being unanticipated by market participants. In fact, Kuttner (2000), when investigating the U.S. interest rate reactions to FOMC decisions, uses federal funds futures contracts to extract the unanticipated component of U.S. monetary policy decisions. However, given the fact that the Bank of Canada did not have fixed announcement dates during our sample period, comparisons with Canadian results are made easier if we use changes in the federal funds rate target as a monetary policy variable in U.S. interest rate regressions, rather than attempt to calculate the unanticipated component of U.S. monetary policy moves.[16]

As Table 10 shows, we find that, although statistically significant, the FOMC decisions provide little added explanatory power (as the adjusted R^2s increase by very little) for U.S. yield movements.[17] In contrast, when official rate changes in Canada are included in the Canadian interest rate regressions, we find that the coefficients are in economic terms large and statistically significant over the 2 January 1995 to 1 October 1999 sample period. Moreover, the value of the adjusted R^2s increased substantially for each interest rate regression from those values reported in Table 6. The greatest relative difference is found for the Canadian futures yield, where the adjusted R^2 jumps from 0.0551 to 0.2017. As we explain below, the futures yield rather than bond yields provides a more direct assessment of the markets' understanding of the Bank's reaction function. Therefore, it seems that, relative to their U.S. counterparts, Canadian market participants are surprised when the Bank changes its target interest rate, and market participants tend to rely very little on (Canadian) macroeconomic announcements to anticipate Bank of Canada rate moves.

16. Because we examine dates only on which the FOMC changed official rates, our methodology is similar to that used in Cook and Hahn (1989), who examined the reaction of bond rates to changes in the federal funds rate.

17. Poole and Rasche (2000) point out that it is more interesting to look at how the market's expectations of future target federal funds rates—as proxied by the one-month-ahead federal funds futures contract yield—react to FOMC decisions. However, they also show that macroeconomic announcements have a strong impact on expected future target rates. Consequently, they argue that market participants have, since February 1994, a period where they indicate the Fed has improved monetary policy transparency, a better understanding of the Federal Reserve's monetary policy reaction function. Given that our sample period begins after 1994, our findings indicating that target federal funds rate changes have little added explanatory power for U.S. yield curve movements are consistent with Poole and Rasche's (2000) findings.

Table 10: Interest rate response when domestic monetary policy changes are included (in addition to Canadian and U.S. macroeconomic surprises)

Yields	Monetary Policy Coefficient, Canada	R^2 ($a\text{-}R^2$)	Monetary Policy Coefficient, U.S.	R^2 ($a\text{-}R^2$)
Futures	0.5338 (0.000)	0.2174 (0.2017)	0.1735 (0.0023)	0.1689 (0.1520)
2-year	0.3515 (0.000)	0.1469 (0.1294)	0.3445 (0.0016)	0.1323 (0.1145)
5-year	0.2301 (0.000)	0.1214 (0.1035)	0.3252 (0.0026)	0.1265 (0.1085)
10-year	0.1369 (0.000)	0.1026 (0.0843)	0.2564 (0.0039)	0.1113 (0.0931)

Notes: The first number is the coefficient; the second number, in parentheses, represents the significance level. Estimated using a Newey-West adjusted covariance matrix. Adjusted R^2 ($a\text{-}R^2$) are presented in the brackets adjacent to R^2 measures.

As Haldane and Read (2000) explain, the short-term rates are particularly relevant for extracting information about the markets' ability to understand how the central bank will react to macroeconomic news. At longer maturities, the markets' uncertainty about the reaction function embodies their views about the central bank's credibility of achieving its (inflation) target. In other words, the longer term yield reactions embody how strongly anchored the markets' expectations are of the inflation target being achieved. Thus the short-term rates provide a cleaner measure of the markets' degree of uncertainty about the central bank's reaction function. Moreover, Haldane and Read show that forward rates, rather than spot rates, better assess the markets' understanding of the conduct of monetary policy, since they provide information about the yield *at* some set date in the future. Spot rates provide information only about the *average* yield expected by the market over some set period going forward. Haldane and Read also show analytically that shorter-term forward maturities (up to two or three years) permit examination of the markets' understanding of how macroeconomic data condition the central bank's monetary policy reaction function. This implies that the estimated reaction of bond yields to target changes (shown in Table 10) are of only indirect use in assessing the markets' level of understanding about the Bank's monetary policy reaction function.

It is interesting to note that Haldane and Read (2000), when examining forward interest rate reactions to monetary policy changes, show that U.S. (and German) interest rates, compared with those in the United Kingdom or Italy, react in economic terms very little to monetary policy

changes. Although we can not compare the results in Table 10 for the spot bond yields with those in Haldane and Read (2000) using forward rates, the results reported for the futures yield may be comparable to the 1-month spot or 1-month forward rates regression results reported in their Table C. We find that our estimate of 0.1735 for the monetary policy decision coefficient from the U.S. futures yields regression (Table 10) is roughly in line with Haldane and Read's significant estimated U.S. monetary surprises coefficient of 0.16.[18] As argued by Haldane and Read and others, the U.S. (and German) monetary policy reaction functions are viewed as being relatively well understood by market participants. However, as Table 10 demonstrates, the response of the Canadian futures yield to monetary policy changes is very large relative to that of the United States, which implies that there is a much greater degree of uncertainty about the reaction function in Canada than in the United States (even after including macroeconomic announcements).

It is possible that the evidence indicating the U.S. market participants' substantial ability to accurately forecast Federal Reserve policy decisions is a result of Federal Reserve officials signalling to the market the future change in the policy rate, rather than the result of the markets' elevated understanding of how the FOMC processes (macroeconomic) information in reaching its monetary policy decision. That is, markets may be able to correctly anticipate FOMC actions, simply because Federal Reserve officials (via speeches) implicitly announce their future monetary policy intentions. However, Poole and Rasche (2000) present evidence that markets are responding to economic fundamentals rather than FOMC signals.

8. Conclusions

In this study, we found that the impact of U.S. macroeconomic news on the Canadian fixed-income markets is significant, and appreciably more important than the impact of domestic Canadian macroeconomic news when using close-of-business interest rate data. This confirms anecdotal evidence garnered by the Bank of Canada's trading desk, which indicates that Canadian market participants actually put much less emphasis on Canadian than on U.S. macroeconomic news releases.

That international macroeconomic events affect Canadian markets should not be too surprising, given that Canada's economy is open and has financial markets that are highly integrated with the global financial system. However, the finding that U.S. macroeconomic indicators have a dominant impact on Canadian financial asset prices, almost to the exclusion of Canadian macroeconomic announcements, is curious. Moreover, these findings contrast with studies based

18. The Haldane and Read (2000) U.S. coefficient estimates are based on a January 1990 to March 1997 sample period.

on other open-economy interest rates, such as Campbell and Lewis (1998) using Australian interest rates, and Brooke, Danton, and Moessner (1999) and Moessner and Gravelle (2001) using U.K. yields.

One reason why Canadian interest rates fail to statistically respond to domestic macroeconomic announcements may be the limited sample size, and, consequently, an insufficient number of macroeconomic announcements to accurately measure, in a statistical sense, their impact on yields. A related possible explanation is that there has not been a sufficient degree of divergence between Canadian and U.S. business cycles since the Bank of Canada began efforts to increase its monetary policy transparency in the early to mid-1990s.

Our study also shows that Canadian financial markets do react to new information, albeit not necessarily Canadian information, within the day of its announcement. This implies that Canadian financial markets efficiently process this information. However, as recent research, such as that by Fleming and Remolona (1999), indicates, more powerful tests of market efficiency can be carried out only by using intraday observations of financial asset prices. This suggests that a future avenue of research examining Canadian market efficiency would entail the use of tick-by-tick data. With such data, and the exact knowledge of the time of the macroeconomic data release, it would be possible to see exactly how prices impound the information on a trade-by-trade basis. In addition, this type of research would allow for a definite resolution of whether the statistical significance of the Canadian employment figures are spurious. Employment data in Canada are released at 7 a.m., while U.S. employment data are released at 8:30 a.m. Eastern Time. Thus, intraday Canadian asset price data would allow for the measurement of two separate asset reactions, which is not possible with daily frequency data. We intend to examine this issue in a separate note using intraday Canadian BAX futures contract data available from the Montreal Exchange.

This study focused on analyzing the markets' perceptions of the Bank's monetary policy reaction function. In a previous Bank study, Muller and Zelmer (1999) present evidence supporting the theory that the Bank's efforts to reduce the public's uncertainty about its monetary policy conduct has been successful. This study has re-examined this issue from a different angle by investigating interest rate reactions to macroeconomic surprises since, in theory, market participants should react vigorously to those indicators they believe to be important for the Bank's monetary policy reaction function. We find that, essentially, interest rates in Canada do not react to domestic data releases, and that there has been no discernible increase in interest rate reactions to macroeconomic data over our sample. This result supports the theory that market participants have not improved their understanding of the Bank's monetary policy reaction function. Although

Muller and Zelmer (1999) present evidence of a decrease in interest rate reactions to monetary policy changes, it seems that this likely reflects the Bank's tendency, during the latter part of our sample period, to mirror FOMC moves.

It is interesting to compare this result to the case of the United States. We found that overall, there seems to be a continued high degree, in relation to the United States at least, of reaction-function-uncertainty in Canada. The Bank's apparent lack of progress in increasing the markets' understanding of what economic variables condition its monetary policy changes is hypothesized to result from the absence of fixed announcement dates for monetary policy changes, and the Bank's past tendency to react to sudden and large exchange rate depreciations.[19]

However, beginning in December 2000, the Bank of Canada moved to a FAD regime whereby decisions on the monetary policy target interest rate are announced on fixed dates, with the dates being announced one year in advance.[20] It would be interesting to update this study in two years' time to see whether this move has led to a significant change in the way Canadian financial markets react to domestic macroeconomic news, relative to domestic official interest rate decisions and U.S. macroeconomic news. One might suppose, for example, that Canadian fixed-income markets might react more strongly to domestic macroeconomic news, and less to official interest rate decisions themselves, since they will know up to which date the monetary authorities will be able to take such news into account. However, this assumes that the Bank will not react, in the coming years, to strong depreciations of the exchange rate (vis-a-vis the U.S. dollar) and, as such, will rid itself of any remaining market perception of targeting exchange rate levels. Clinton's (2001) analysis, based on the commodity-sensitive currencies of Australia, New Zealand, and Canada, shows that a monetary policy framework that features a low propensity to change official interest rates in reaction to exchange rate movements produces better macroeconomic outcomes.

Given the use of (longer-term) spot interest rates in this study rather than forward interest rates, we are not able to directly differentiate between the market participants' reaction function uncertainty that emanates from their poor knowledge of how the Bank reacts to a series of domestic economic data releases and the uncertainty arising from monetary policy credibility. Future work would examine the changes in various forward interest rates in reaction to monetary policy changes, in addition to asset price reactions to the macroeconomic surprise variables. The

19. See Clinton and Zelmer (1997) for a detailed discussion of the interaction between monetary policy and foreign exchange market volatility in Canada.

20. Note also that within the FAD regime, the Bank is committed to not changing official rates between fixed announcement dates or respond directly to exchange rate movements—except in extreme circumstances.

additional use of macroeconomic data allows for a more complete examination of the markets' understanding of the authorities' reaction function. Further, we propose using vector error-correction econometric techniques that take into account the cointegration between Canadian forward and spot interest rates as shown in Gravelle, Muller, and Stréliski (1999). By estimating a system of equations using a vector error-correction model, rather than a series of regressions for each interest rate variable, we can estimate the cointegration relationship between these interest rates, as well as take advantage of the efficiency gains that result from jointly estimating a system of equations. We intend to follow up on this research work in a separate study.

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Appendix A

A.1 Properties of the Macroeconomic Indicators and Their Forecasts

We follow Joyce and Read (1999) in the method of testing for the unbiasedness and efficiency of the median forecasts of economic indicator releases. Table A1 shows the results of tests for the unbiasedness of the MMS median forecasts. We test for unbiasedness by regressing the actual values of the indicator releases, $x_{i,t}$, on the values of the median forecast, $x^{e}_{i,t}$, and a constant term,

$$x_{i,t} = a + b\, x^{e}_{i,t} + \varepsilon_t$$

where t denotes months. We test for unbiasedness by testing the hypothesis that a=0 and b=1, using a Wald test. This hypothesis is rejected at the 5 per cent level only for the case of Canadian raw material prices; in all other cases, the hypothesis cannot be rejected at that level.

Table A1: Tests for unbiasedness (releases between January 1995 and July 2000 for Canadian data)

	CPI	CPIEX	PPI	RAW	RSL
a (t-statistic)	0.1046 (1.7)	0.1626 (2.29)	-0.1471 (-2.35)	-0.0972 (-0.49)	-0.2627 (-1.91)
b (t-statistic)	0.9335 (28.4)	0.8985 (20.9)	1.2049 (6.5)	1.4624 (9.7)	1.1720 (5.24)
R^2	0.92	0.87	0.39	0.60	0.30
Durbin-Watson statistic	2.05	2.10	2.53	2.64	2.63
Wald test of restrictions (a,b)=(0,1): F-statistic [p-value]	2.10 [0.13]	2.79 [0.068]	3.00 [0.057]	4.74 [0.012]	2.21 [0.12]

	UNP	EMP	WAG	MTB	GDP	CA[a]
a (t-statistic)	-0.1659 (-0.74)	14.1653 (1.11)	0.2549 (1.89)	0.4428 (1.84)	-0.0641 (-1.54)	1.1687 (0.73)
b (t-statistic)	1.0177 (40.0)	0.3524 (0.79)	0.8309 (10.11)	0.7967 (8.13)	1.102 (9.09)	1.0433 (9.15)
R^2	0.96	0.01	0.62	0.51	0.57	0.81
Durbin-Watson statistic	2.03	1.89	2.30	2.03	2.48	1.83
Wald test of restrictions (a,b)=(0,1): F-statistic [p-value]	0.36 [0.70]	1.36 [0.26]	2.11 [0.13]	2.27 [0.11]	1.27 [0.29]	0.30 [0.75]

a. Including four lags in regression, since data are quarterly.

We test for (weak-form) efficiency of the median forecasts by regressing the surprise in an indicator release on lagged values of the actual values of the data releases,

$$x_{i,t} - x^{e}_{i,t} = a + b_1 x_{i,t-1} + b_2 x_{i,t-2} + \ldots + b_k x_{i,t-k} + \varepsilon_t$$

where k=12 lags are included for monthly data, and k=4 lags are included for quarterly data. Table A2 shows the results. We then test the hypothesis that all the lagged coefficients are jointly equal to zero, using a Wald test. This hypothesis can be rejected at the 1 per cent level for Canadian CPI excluding food and energy; in all other cases, this hypothesis cannot be rejected at the 5 per cent level.

Table A2: Tests for efficiency (releases between January 1995 and July 2000 for Canadian data)

	CPI	CPIEX	PPI	RAW	RSL
R^2	0.26	0.15	0.20	0.27	0.32
Durbin-Watson statistic	2.09	1.99	2.00	1.94	2.10
Wald test of all lagged coefficients restricted to zero: F-statistic [p-value]	1.26 [0.28]	2.69 [0.009]	1.21 [0.31]	1.32 [0.25]	1.54 [0.15]

	UNP	EMP	WAG	MTB	GDP	CA[a]
R^2	0.21	0.15	0.14	0.21	0.36	0.039
Durbin-Watson statistic	2.07	1.94	2.11	2.18	2.06	1.41
Wald test of all lagged coefficients restricted to zero: F-statistic [p-value]	0.95 [0.51]	0.73 [0.72]	0.56 [0.86]	0.92 [0.53]	1.84 [0.07]	0.13 [0.97]

a. Including four lags in regression, since data are quarterly.

Appendix B

Table B1: Changes in the federal reserve funds rate target and the Bank of Canada target overnight rate, January 1995 to August 2000 (in basis points)

Date	28/6/00	17/5/00	16/5/00	22/3/00	21/3/00	3/2/00	2/2/00	21/12/99
Fed Funds	x		50		25		25	x
Bank of Canada		50§		25§		25§		
Date	17/11/99	16/11/99	5/10/99	24/8/99	30/6/99	18/5/99	4/5/99	31/3/99
Fed Funds		25	x	25	25	x		
Bank of Canada	25§						-25	-25ø
Date	30/3/99	3/2/99	22/12/98	18/11/98	17/11/98	16/10/98	15/10/98	29/9/98
Fed Funds	x	x	x		-25		-25*	-25
Bank of Canada				-25§		-25§		-25§
Date	27/8/98	18/8/98	1/7/98	19/5/98	31/3/98	4/2/98	30/1/98	16/12/97
Fed Funds		x	x	x	x	x		x
Bank of Canada	100‡						50‡	
Date	12/12/97	25/11/97	12/11/97	1/10/97	30/9/97	19/8/97	2/7/97	26/6/97
Fed Funds			x		x	x	x	
Bank of Canada	50‡	25‡		25ø				25
Date	20/5/97	25/3/97	5/2/97	17/12/96	13/11/96	8/11/96	28/10/96	16/10/97
Fed Funds	x	25	x	x	x			
Bank of Canada						-25	-25	-25
Date	2/10/96	24/9/96	22/8/96	20/8/96	9/8/96	19/7/96	3/7/96	21/5/96
Fed Funds		x		x			x	x
Bank of Canada	-25		-25		-25	-25		
Date	18/4/96	26/3/96	21/3/96	31/1/96	25/1/96	19/12/95	15/11/95	31/10/95
Fed Funds		x		-25		-25	x	
Bank of Canada	-25		-25	-25§	-25	-25§		-25
Date	26/9/95	28/8/95	22/8/95	9/8/95	10/7/95	6/7/95	13/6/95	2/6/95
Fed Funds	x		x			-25		
Bank of Canada		-25		-25	-25	-25§	-25	-25
Date	23/5/95	8/5/95	28/3/95	16/2/95	1/2/95	17/1/95	12/1/95	10/1/95
Fed Funds	x		x		50			
Bank of Canada		-25		50‡	50‡§	50‡	50‡	50‡

Notes: * indicates when the FOMC changed the target federal funds rate in-between a scheduled meeting. ‡ indicates when the Bank of Canada changed its target rate in reaction to foreign exchange market instability (see Muller and Zelmer 1999 and Murray, Zelmer, and Antia 2000 for more on this). x indicates FOMC meeting dates where the target federal funds rate was left unchanged. § indicates the Bank of Canada target rate changes that were announced within 24 hours after FOMC decisions were announced and were of the same size and direction as federal funds rate changes. ø indicates the Bank of Canada target rate changes that were announced within 24 hours after FOMC decisions, but did not mirror the federal funds rate changes. Note that the table does not list the 22 August 2000 FOMC meeting that occurred within our sample period. The target for federal funds rate was not changed on that date.

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